GERMAN ECONOMIC TEAM IN BELARUS

76 Zakharova Str., 220088 Minsk, Belarus. Tel./fax: +375 (17) 236 1147, 236 4395
E-mail: bmer@ipm.by. Internet: http://research.by/

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Renewable Energy Resources: the Past, Present and Future

Summary

Renewable energy sources (RES) have numerous economic and environmental advantages. They could replace fossil fuels and reduce dependence on imported energy, create additional opportunities for some industries and agriculture, reduce green house gas emission and other types of pollution. That is why there is a clear trend in most developed countries towards increased RES usage. However, some obstacles constrain more active development. Among the most prevalent are high initial investments in infrastructure and technologies, and market 'failure' to monetize positive externalizes. As conventional sources of energy become increasingly expensive, and environmental concerns grow, interest in RES is growing as well. The challenge facing policy makers is how to create the conditions for the development of RES.

This background paper describes some of the existing concepts related to the energy policy of a country and analyzes different RES advantages and limitations. As well the paper outlines some EU experiences of using and stimulation renewables.

1. Introduction

The use of renewable energy sources (RES) is as old as humanity. Recently, however, interest in RES has increased dramatically. Environmentally, RES are seen as a means of reducing the use of traditional fossil fuels and the associated emissions of greenhouse gases and other pollutants. Strategically, RES may provide some countries with an opportunity to reduce dependence on imported supplies of primary fuels. RES are also seen as a means of stimulating economic activity in agriculture and creating additional employment and strengthening energy security in rural areas.

At the same time, however, RES are often costly and their development and use dependent on various forms of direct and indirect subsidization. This can lead to market distortions and to misuse of scarce economic resources.

This paper contains background information on RES, providing readers with key definitions and concepts and a discussion of the experience that the EU has made with RES so far. This background information is designed to provide a basis for an ensuing GET Policy Paper in which we discuss the opportunities and threats that the development of RES poses for Belarus. To avoid confusion, it is important that any such discussion be based on a transparent set of widely accepted definitions and concepts.

This background paper is organized as followings. In section 2, worldwide use of RES, the main types of RES, and their potential benefits and limitations are described. In section 3, different criteria that are used to evaluating energy sources and that are often used in connection with RES are presented. Section 4 provides an overview of the EU's experience with RES. Some conclusions are presented in section 5.

2. Renewable energy

2.1 The extent of RES use in the world

Although RES have been known and used for thousands of years, the general concept of renewable energy was introduced in the 1970s as part of an effort to move beyond nuclear and fossil fuels. *The most common definition is that renewable energy is energy taken from a resource that is replaced rapidly by a natural, ongoing process.* Under this definition, energy sources such as peat, fossil fuels and nuclear power are not renewable.[1]

The role of RES differs across regions and countries. It depends on a country's demand for energy, its own fossil fuel resources and its ability to import such fuels. It also depends on climate, geography and the availability of RES. According to the International Energy Agency (IEA), the share of RES in global energy consumption was 13.4% (OECD – 5.7%, Non-OECD – 21.9%) in 2002 (see Appendix, Figures 6-7). The largest share of RES in primary energy consumption is found in Asia (33%). In the EU-15 this share is about 5.7% and in Latin America 28.4%. Sometimes the apparent negative correlation between the share of RES on the one hand and economic development on the other is interpreted as meaning that RES use is a sign of a 'backward', underdeveloped economy. True, the path of economic development does initially lead from 'primitive' technologies that often involve RES (e.g. subsistence households burning wood for heating and cooking in developing countries), to an increasing dependence on fossil fuels in the course of industrialization. However, as fossil fuels become scarcer and more costly, there are indications that the ensuing path leads 'back' to the 'high-tech' use of RES (see Figures 8-10 in Appendix).

[1] There may be a sense in which these energy resources, strictly speaking, are renewable. However, the time frames and geological processes involved in the replenishment, for example, of peat and fossil fuel stocks make them effectively non-renewable.

2.2 The main types of RES

There is a wide variety of different sources of renewable energy. In the following we list and briefly discuss the most important of these sources (for more information, see Table 1 in the Appendix).

Biomass. Biomass includes wood, forest product wastes, agricultural residues and wastes such as manure, energy crops and the organic component of industrial waste and municipal solid waste. Biomass can be burned directly or processed into biogas or liquid biofuels by a large variety of technical means (e.g. fermentation). Biogas and biofuels, in turn, can be converted into heat and electricity (e.g. by combustion or using fuel cells), or used as fuels for transportation. All of these steps require resources and appropriate infrastructure.

Unlike other renewable energy sources, biomass can be converted directly into liquid fuels – biofuels – for transportation needs or energy generation. These fuels are derived from agriculture, forestry or other organic sources. The two most common types of biofuels are ethanol and biodiesel.

<u>Ethanol</u> is an alcohol, the same found in beer or wine. It is made by fermenting any biomass high in carbohydrates (starches, sugars, or celluloses) through a process similar to brewing beer. Since the early 1990s, ethanol is mostly used as a fuel additive to reduce a vehicle's carbon monoxide and other smog-causing emissions. Brazil has been a leader worldwide in promoting the use of ethanol derived from its domestic sugar industry. Blending ethanol into gasoline also reduces toxic pollutants found in gasoline but causes more so-called ‘evaporative emissions’ to escape. In order to reduce these emissions, gasoline requires extra processing before it can be blended with ethanol. When burned, ethanol does release carbon dioxide, a greenhouse gas. But growing the biomass (e.g. sugar cane) required to produce ethanol also binds greenhouse gases, since plants use carbon dioxide and produce oxygen as they grow.

<u>Biodiesel</u> is made by combining alcohol (usually methanol) with vegetable oil, animal fat, or recycled cooking greases. It can be used as an additive to reduce vehicle emissions or in its pure form as a renewable alternative fuel for diesel engines. It results in much lower emissions of almost every pollutant: carbon dioxide, sulfur oxide, particulates, carbon monoxide, air toxics and unburned hydrocarbons. Biodiesel does increase nitrogen oxide emissions by about 10 %, however. The production cost of ethanol and biodiesel have declined substantially over the past ten years, while the prices of fossil fuels have increased. In section 3 below we discuss the competitiveness of biofuels and other RES in detail.

Geothermal. Geothermal energy is available as heat emitted from within the earth, usually in form of hot water or steam. Geothermal energy is very site specific. High temperature geothermal resources can be used to generate electricity, but low temperature geothermal resources are more wide-spread and are employed in various direct uses such as district heating, industrial and agricultural processing (e.g. greenhouses, aquaculture), balneology and in conjunction with groundwater heat pumps. The term ’geothermal energy’ refers to the part of the earth’s heat that could be recovered and exploited by humanity.

Hydropower. The exploitation of water for energy production began more than 2.000 years ago when water was harnessed by water wheels to grind grains into flour. Nowadays hydroelectric generation using dammed rivers is the most important use of hydropower, for example in the United States, Canada and Norway. Current efforts are being directed towards finding ways of harnessing ocean waves and tidal power. To deal with seasonal and annual variability of hydropower production, counties such as Norway have increased international electricity interconnections, exporting power in wet seasons and importing it in dry seasons. This system has reduced prices and increased collective energy security in Norway and the other participating countries.

Solar photovoltaic. Photovoltaic technology involves the direct generation of electricity from light. The process is generally exploited by use of semiconductor materials, which can be adapted to release charged particles, forming the basis of electricity. The most common semiconductor material used in photovoltaic cells is silicon, which is widely available, but must be purified before it can be used. Since the distribution and intensity of sunlight over time and space is uneven, photovoltaic energy, like solar thermal and wind power (see below), places special demands on energy infrastructure. While photovoltaic electricity can replace other sources or electricity when the sun shines, backup conventional generation capacity must be maintained for 'rainy days'.

Solar thermal. Solar thermal technologies transform solar radiation into energy for heating or cooling. Household hot water is the most common application of solar thermal technology. There are three basic solar thermal electric technologies: towers, dishes and troughs. The systems operate with a thermal phase, allowing either thermal storage or back-up fuels to offset intermittency and thus increase the commercial value of the energy produced. Recent trends include direct steam generation. Large producers of solar hot water technologies are the United States, Japan, Australia and Turkey.

Wind power. The commercial development of grid-connected wind generators started after the oil price crises in the 1970s. As the costs of wind turbines have steadily declined, technical reliability has increased and the last decade has seen an explosive growth in the development of wind power (see, for example, Figure 8). Growth in installed capacity has been particularly notable since the mid-1990s because of technical improvements and turbine size up-scaling as a result of research and development, often significant subsidization and the development of the infrastructure necessary to support development, manufacturers, installers and operators.

2.3 The benefits of RES

Investments in RES could generate significant advantages:

- For some countries, increased use of RES could reduce dependence on imports of fossil fuels and/or the uranium needed for nuclear power generation. As these imports generally come from a limited number of sometimes politically unstable countries or regions, reducing dependence can convey strategic benefits, reduce the potential for conflict, and increase stability.
- As the prices especially of fossil fuels have increased dramatically in recent years, reducing dependence on fossil fuel imports could improve a country's balance of payments and macroeconomic stability.
- Increased use of RES could foster the development in a country of technologies (e.g. fuel cells, biotechnology) that are expected to play a key role in determining future international competitiveness.
- RES could provide new opportunities for some agricultural industries and rural areas. Agriculture and rural areas are a key potential source of biomass that is the basis for many RES. Local energy generation can also improve the competitiveness of remote areas where imported energy is especially expensive.
- Compared with fossil fuels and nuclear power, the use of RES can eliminate or reduce air emissions (carbon dioxide, nitrogen oxide, sulfur dioxide emissions which are widely produced by power plants) as well as reduce water

consumption, thermal pollution, waste and the threat of radioactive contamination. Hence, RES can help reduce negative externalities such as global warming due to greenhouse gas emissions. In this way they can contribute to sustainable development which leaves future generations with an intact environment and dependable energy resources.

- The use of RES can also help to fulfill international obligations such as the Kyoto Protocol.[2]

2.4 Restrictions on the use of RES

RES have an immense potential. However, this potential has to be realized at a reasonable cost. The realization of the benefits listed above depends on the development of technologies and infrastructure that are economically competitive. So far, with few exceptions, RES have been more expensive than alternative energy sources such as fossil fuels.[3] However, while the costs of fossil fuels and nuclear power have tended to increase over time (the former dramatically in recent months), the costs of tapping many RES have been falling. Indeed, some analysts are convinced that with crude oil priced in the neighborhood of 70 $/barrel on world markets, a threshold has been crossed over which some RES are now economically competitive. In the following we discuss factors which have limited the expansion of RES in the past:

Infrastructure. Developing new RES often requires large initial investments to build infrastructure. For example, making biodiesel for automobiles widely available would involve establishing a distribution system for biodiesel including, for example, separate pumps at gas stations. In the case of wind power, developers must find publicly and economically acceptable sites with access to transmission lines, and must monitor potential sites to determine whether they are suitable.

Standards and regulation. Due to the relative newness of many RES technologies, important regulatory standards (for example, safety or emission (smell) standards for biogas units) and procedures for granting permits, etc. have not yet been developed in many countries. This can limit the process of installation and use.

Technology and economies of scale. Many RES technologies are relatively new and so far have be realized only as prototypes or in fairly small experimental or niche markets. As a result, potential cost reductions due to technological advances and learning by doing on the one hand, and economies of scale in the production of marketable units on the other, have not been realized. These potential cost reductions can be significant, as exemplified in Figure 1, which shows that the cost of producing energy from wind power fell by 50% between 1990 and 2005 (see also Figure 8 and Figure 10).

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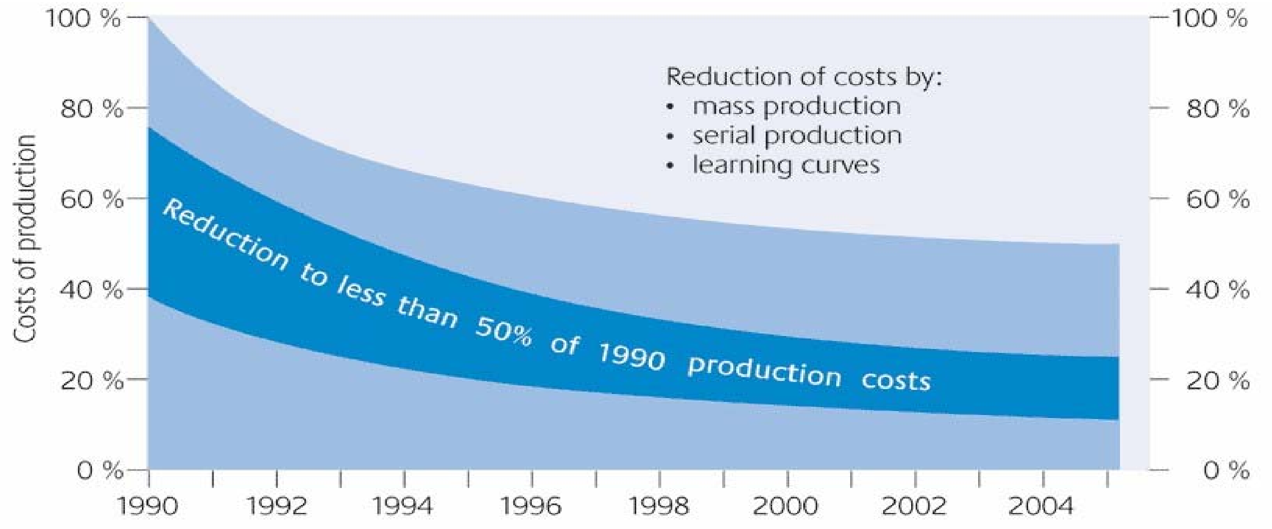
[2] Signatories to the Kyoto Protocol have agreed to legally binding quotas to limit or reduce CO_2 emissions by the year 2010. The Kyoto Protocol also defines the rules for the international trade in greenhouse gas emissions. On August 12, 2005 Belarus joined the Kyoto protocol. According to some estimates, joining the Kyoto protocol will enable Belarus to receive revenues of at least of USD 325 m from selling free quotas for greenhouse emissions. Moreover, the Kyoto protocol will create opportunities for the country to get additional investment revenues in the form of Joint Implementation projects in the fields of energy savings or technologies aimed at emission reductions. See IPM-GET Policy Paper 06/03 http://ipm.by/index.pl?topicid=bdcb4831&skip=20.

[3] Exceptions include hydropower (e.g. Canada, Norway) and geothermal power (e.g. Iceland) in some countries, and the widespread (but often unsustainable) use of firewood in many developing countries.

Figure 1. Reductions in the costs of producing wind energy in Germany between 1990 and 2005



Source: German Energy Agency, 2005.

The different shading of the curves in Figure 1 are used because of different cost categories for different sizes of wind power turbines and a range of costs for producing wind power on different places all over Germany where the wind intensity differs.

Failure to value public benefits. RES could play an important role in reducing the incidence of important negative externalities such global warming due to the emission of greenhouse gases. They can also contribute to the diversification of energy sources and reduce strategic dependence. However, the value of these benefits is difficult to quantify. For example, neither the exact influence of greenhouse gases on the rate and extent of global warming, nor the impact of global warming on human welfare is known with certainty. The value of reduced dependency on imported energy is also hard to measure. Furthermore, since some of these benefits are public in nature, it is difficult to devise market mechanisms that ensure that they will be paid for.

Uncertainty. Recent price increases for fossil fuels have increased interest in RES. Oil and gas prices are notoriously volatile, however, and the resulting uncertainty hinders investment, and can lead to 'boom and bust' cycles of over- and under-investment. Investments in RES that appear profitable today, might not be profitable if oil prices fall back below USD 50 for 1 barrel in the medium term. Since such investments (for example in a windmill or a biogas unit) are long term, potential investors might be discouraged by the uncertain prospects for profitability over the long run, even though the short run prospects are positive.

Such long-run uncertainty in costs and results carries a risk for misallocation of capital investments. Under such conditions, investment decisions should be determined by the market, where private investors are personally responsible for use of their funds. In contrast, large public investments are more likely to underestimate the risks of such projects which can lead to the loss of investments funds, higher than necessary energy costs and idle capacity.

Backup generation capacity. Finally, many types of RES, in particular, wind and solar energy, cannot guarantee stable fuel supply at all times. As a consequence, backup conventional generation capacity must be maintained in order to guarantee the secure reliable functioning of the energy complex. Typically maintaining such alternative capacity creates additional costs which has to be considered.

Faced with these restrictions on the expansion of RES use, policy makers in some countries have responded with policies to encourage research and development in the field of RES, to develop standards for the use of RES, and to subsidize investment in RES facilities. Several members of the EU have been at the forefront of these developments, and RES policy in the EU is discussed in section 4 below. First, however, we provide an overview of the various ways in which energy sources can be evaluated.

3. The evaluation of energy sources

Different sources of energy can be evaluated and compared using a number of different criteria. These include the concepts of energy balance, net energy gain, environmental balance, cost-benefit ratio and energy security.

Energy balance. In physics, the energy balance is a systematic presentation of energy flows and transformations in a system. According to the first law of thermodynamics, energy cannot be created or destroyed, only modified in form, and an energy balance is a detailed accounting of these modifications.

From an energy economics point of view, the energy balance of a country is an aggregate balance of all activities and sources of energy production, import, export and primary consumption. Creating such a balance requires aggregating different sources of energy, for example in tons of oil equivalent. There are national energy balances and global energy balances, generally compiled on an annual basis. The Belarusian energy balance, as an example, is reproduced in Table 2 in the Appendix. Such national balances provide insights into the relative shares of different energy sources and a country's dependence on imported energy.

Net energy gain (NEG). This concept measures, at the level of an individual energy source, the difference between the energy required to harvest that energy source and the energy provided by using that source, i.e. the difference between the energy produced by 1 kilogram of a certain fuel (e.g. biodiesel, petroleum, uranium) and the energy needed to produce that kilogram (e.g. extraction such as drilling or cultivation of energetic plants, transportation, refining, etc). For example, during the 1920s 50 barrels of crude oil were extracted for each barrel of crude used in the extraction and refining process. Today, only 5 barrels are harvested for each barrel used. When the NEG is less than one, then the corresponding source does not contribute net energy to an economy. For example, in the early days of photovoltaic cells, their NEG was less than 1; as a result of technological progress it is now greater. The NEG is sometimes expressed in terms of the time required to amortize a generation unit such as a wind turbine or a photovoltaic cell – i.e. the time that that unit must operate to generate and thus recover the energy that went into making it. Currently, the amortization of a wind turbine requires 2 to 5 months; for hydroelectric power and photovoltaic units the corresponding times range from 24 to 36 and 65 to 122 months, respectively.

Clearly, an RES with an NEG of less than one cannot generate many of the benefits listed in Section 2 above, such as reduced dependence on imports or reduced emission of greenhouse gases. Furthermore, an RES with an NEG only marginally greater than one may have to operate for a long time before it begins to produce net new energy. In this case it will take correspondingly long before the benefits listed above begin to be realized.

Energy security. Energy security – access to a dependable and sufficient supply of energy at reasonable prices – is an important component of economic and national security. For net importers of energy, especially those that are dependent on a single or very few energy suppliers, dependence can be seen as a threat to national sovereignty. A variety of steps can be taken to reduce dependence and increase energy security. These include:

- Increasing the efficiency of domestic energy use so that national GDP is produced using little energy (domestic or imported) as possible;
- Diversifying a country's sources of energy imports to reduce dependence on individual sources;
- Developing domestic energy sources to reduce dependence on imports. These domestic energy sources can include, but are not limited to RES;
- Maintaining strategic energy stocks that can be used when import supplies are temporarily interrupted; and
- Maintaining good economic and political relations with countries that play an important role on world energy markets, and with neighbouring countries that control energy infrastructure that might be needed in a crisis.

A policy for increasing energy security will usually involve elements of all of these steps. All of these steps involve costs which must be carefully evaluated and compared with the (often intangible) benefits of greater energy security.

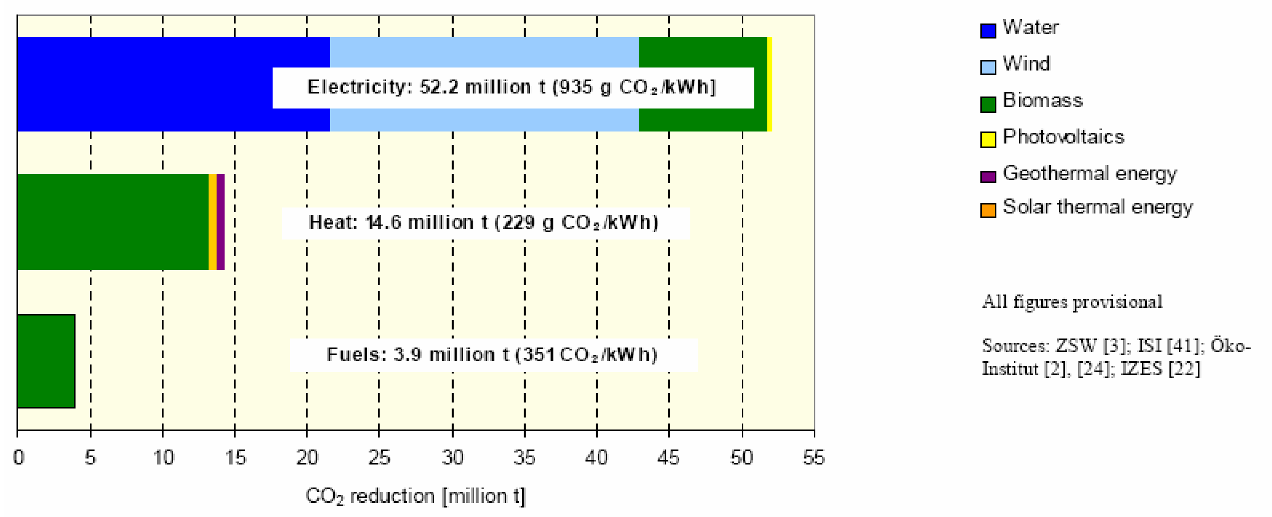
Environmental balance. The combustion of fossil fuels produces emissions that can create negative externalities. These externalities can be local (smog), regional (acid rain) or global (global warming).[4] Some of the most important emissions are:

- Sulfur oxides (SO_x), which cause acid rain and are a source of fine particles in the air;
- Nitrogen oxides (NO_x), which can irritate the lungs and decrease resistance to respiratory infections;
- Carbon dioxide (CO_2), which is the most important of the greenhouse gases, which contribute to global warming by trapping heat in the earth's atmosphere. Electricity generation using fossil fuels such as oil, gas and coal is the largest industrial source of CO_2; and
- Other pollutants such as carbon monoxide and various hydrocarbons, which cause negative impacts on people's health and contribute to smog.

The use of RES can reduce such emissions, leading to an improved environmental balance (e.g. a lower level of greenhouse gas emission per unit of energy produced). For example, while burning fossil fuels leads to a net emission of CO_2, burning wood only returns to the atmosphere the CO_2 that the growing tree had removed. If a new tree is planted to replace the old, using wood as a source of energy can eliminate net CO_2 emissions. Such a CO_2 balance is only partial, however, and generating an overall balance that accounts for and aggregates all of an energy source's environmental effects is a very difficult task. As Figure 2 illustrates, RES use can lead to significant reductions in emissions, for example of $C0_2$. In 2004, around 70 million tonnes of CO_2 were avoided through the use of RES in Germany. Without RES use, total CO_2 emissions (approx. 830 m tonnes) would have been 8.4% higher. In contrast, the contribution of RES to primary energy consumption was only 3.6 %.

[4] Energy use can produce other negative externalities beside gas and particle emissions. For example, in the process of electricity generation with fossil fuels as much as 2/3 of the energy released is not transformed into electricity but rather released as heat into the atmosphere or into water used as a coolant. The latter can upset aquatic ecosystems. Nuclear power generation can lead to problems with radioactive contamination and radioactive waste disposal. We focus on greenhouse gasses due to their current importance in energy policy discussions.

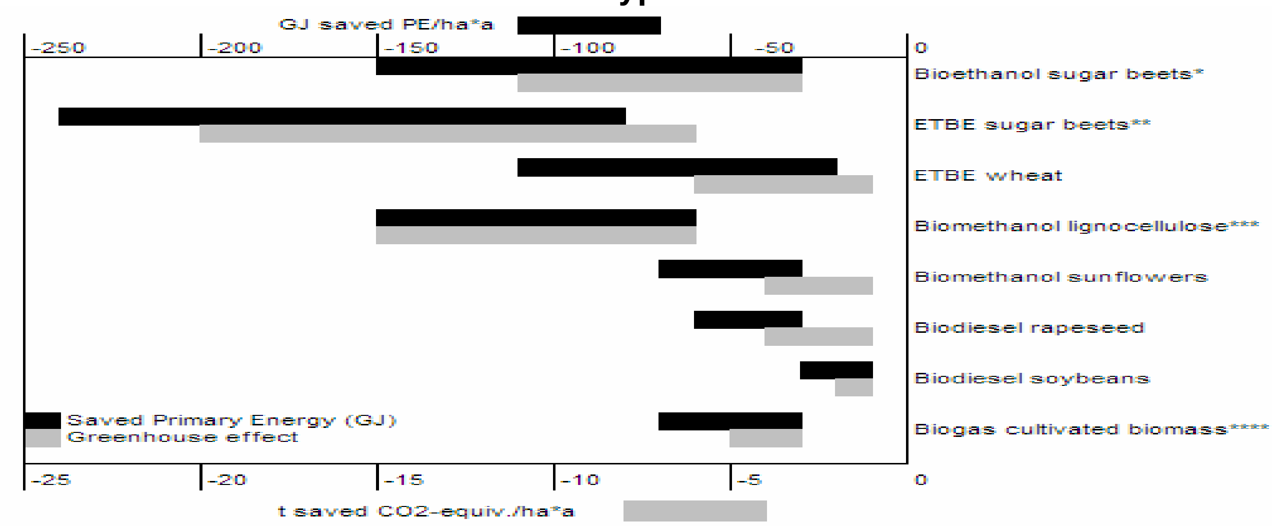
Figure 2. Total CO_2 reduction through the use of renewable energy sources in Germany 2004



Source: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, 2005.

Figure 3 illustrates that the reductions in emissions and the savings for primary energy per ha and year that can result from different types of biofuels vary widely. In Figure 3, the zero mark means that the $C0_2$ emissions or primary energy use are balanced, while negative values imply advantages for the biofuels, in other words that primary energy or CO_2 equivalent emissions are saved in the total balance. The range of savings within individual biofuel technologies is also broad, depending on the process used, the age of the production facility, the source of the raw material for the biofuel, etc. While all of the different types of biofuel included in Figure 3 can reduce emissions and the use of fossil fuel, exact reductions vary from case to case and one should be wary of making precise pronouncements.

Figure 3. Range of Energy and Greenhouse gas balances for different types of biofuels*



Source: Institute for Energy and Environmental Research, Heidelberg, Germany, 2004.

Cost-benefit ratio. Economists use cost-benefit analysis (CBA) to evaluate investments and policy measures (project). CBA compares the costs and benefits that arise as a result of a project with a view to identifying projects that generate cost-

* Bioethanol – for definition please see chapter 2; ** ETBE = Ethyl Tertiary Butyl Ether (ETBE is produced by mixing ethanol and isobutylene and reacting them with heat over a catalyst. ETBE can then be blended into petrol and burnt in an engine for use as a road fuel); ***Biomethanol cellulose = Can be produced from synthesis gas as a result of biomass gasification. **** Biogas – is produced from the anaerobic fermentation of organic materials.

benefit ratios that are less than one (i.e. for which benefits exceed costs). An efficient project is one that generates desired benefits (e.g. a reduction in dependence on imported energy) at the lowest possible cost and, therefore, has the correspondingly lowest cost-benefit ratio.

In theory, CBA is the most comprehensive means of evaluating and comparing energy sources, as it incorporates all of the issues (environment, net energy gain, energy security) discussed above. In practice, however, CBA is often difficult to carry out comprehensively. First, to accurately measure a project's costs and benefits, one must also measure the costs and benefits that would arise in the absence of this project. Second, a comprehensive CBA must account for all relevant costs and benefits, even though many of these are difficult to forecast or estimate. This applies to many of the environmental costs and benefits as outlined above. Finally, calculating a cost benefit ratio involves aggregating all of the costs and benefits caused by a project. This aggregation is usually done in monetary term – i.e. by measuring all costs and benefits in Rubles, Euro or some other currency. Some costs and benefits – such as the destruction of unique biological niches caused by harvesting peat – are very difficult to value in monetary terms, however. Different implicit valuations of factors such as 'environmental damage' or 'energy dependency' often underlie differences of opinion in policy debates on the pros and cons of subsidizing RES.

4. Experience with RES in the EU

The EU Commission's Green Paper entitled "Towards a European strategy for the security of energy supply", published in 2001[5], highlighted the high energy dependency of the European Union. The EU now depends on imports to meet 50% of its energy needs. This is expected to increase to 70% in 2030, with an increasing reliance on oil and gas. This situation presents many economic, political and environmental risks. If conventional fossil fuels and nuclear power will remain key sources of energy, there is a broad consensus that RES can contribute to reducing these risks.

Hence, since 2000 the EU has set two indicative targets for renewable energy:

- to increase the share of electricity generated by renewable energy in the EU-15 to 22% by 2010 (compared with 14% in 2000); and
- to increase the share of biofuels in diesel and petrol used for transport in the EU-15 to 5.75% by 2010 (compared with 0.6 % in 2002).

Along with the 'old' EU-15, the ten new Member States of the EU are also commited to the production of electricity from RES. To this end, indicative national targets for each new Member State are set out in their Accession Treaties. These targets mean that the collective target for the share of electricity from renewable energy in the EU-25 is 21% by 2010. With the measures that have been put in place, the Commission estimates that the share of RES in gross domestic energy consumption in the EU-15 is on course to reach 10% by 2010.

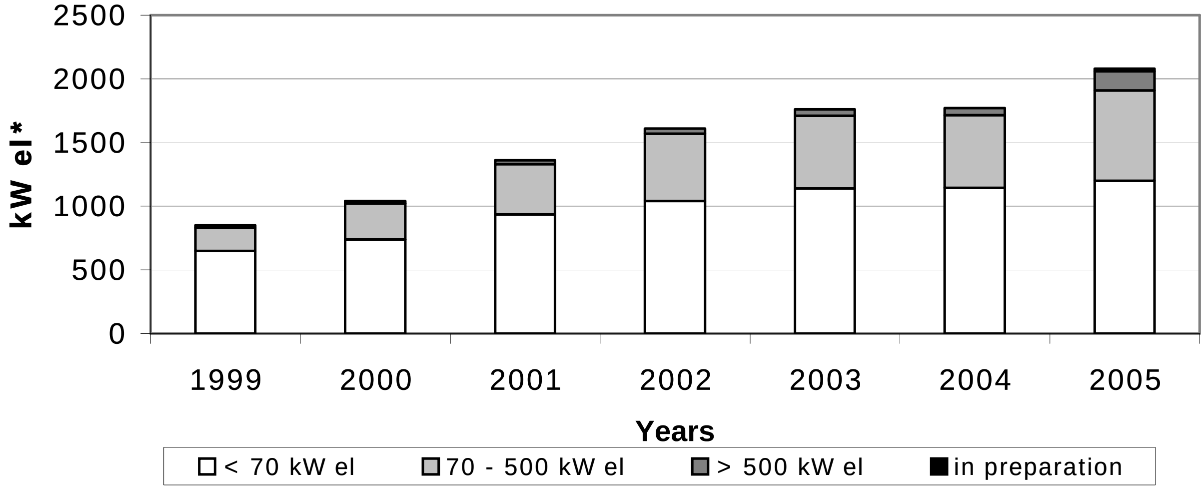
Individual EU Member States are pursuing these goals with different tools and with different urgencies. As Figure illustrates, wind power has developed very rapidly over the last decade, with Germany, Spain and Denmark playing leading roles. As Figure shows, however, wind power still plays a fairly minor role in total energy generation when compared with hydropower and biomass. Currently, one of the most dynamic areas of RES in the EU is biogas generation using agricultural residues (e.g. manure, straw, sugar beet pulp) or crops specifically produced for that purpose (e.g. maize)

[5] For further details refer to the EU Commission's Green Paper, URL: http://europa.eu.int/comm/energy_transport/doc-principal/pubfinal_en.pdf.

and as figure 4 shows, the number of biogas plants e.g. in Germany has more than doubled over the last 5 years.

For the most part, RES development in the EU is highly subsidised. In Germany, the Erneuerbare Energien Gesetz (EEG) obliges the companies that generate and distribute electrical power to purchase electricity generated using RES at guaranteed prices.[6] Without these guarantees and prices, the electricity generated with RES could not compete with electricity generated using fossil fuels (figure 5).

Figure 4. Number of Biogas plants in Germany (2004).

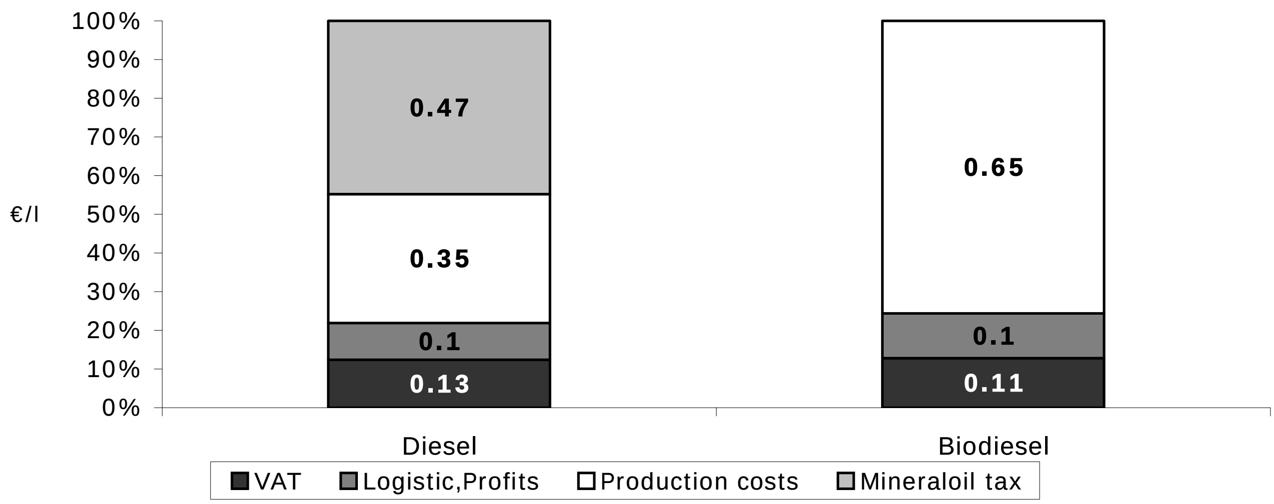


Note: kW $_{el}$ = Kilowatt electricity

Source: Institute for energy and environment, Leipzig, Germany with data from KfW (2004).

The high prices that electricity generators are obliged to pay, for example for wind power, are passed on to end-users (households and industry), who pay higher energy bills as a result. Effectively, therefore, electricity generation based on RES is subsidised by end-users in Germany.

Figure 5. The composition of consumer prices for diesel fuel in Germany



Source: Bergmann and Lakemeyer (2005); calculations based on prices for 2004.

In the area of fuel for transportation (e.g. biodiesel, ethanol) subsidisation generally takes the form of exemptions from fuel taxes. As figure 5 shows, roughly 60% of the consumer price of a litre of diesel fuel in Germany is the result of taxes (VAT and

[6] For further details about the German EEG please have a look on this webpage: http://www.erneuerbare-energien.de/inhalt/5996/20049.

mineral oil tax). Biodiesel (produced for example using rapeseed) is exempt from the mineral oil tax. As a result, it is competitive even though it costs more to produce than conventional diesel. This system of subsidisation via tax exemptions has important fiscal implications: in Germany the annual foregone tax revenues are estimated at roughly 350 million Euro, and these will continue to grow if energy prices climb as they did last months and the share of biodiesel in total diesel fuel use increases.

In addition, the need to maintain backup generation capacities based on fossil fuels lower the potential for reducing total generation costs, and is said to have driven up electricity prices in Germany as well.

Critics of this system argue that higher energy prices due to the EEG reduce the international competitiveness of the German economy, and that the EU and its Member States are simply using RES such as biodiesel and bioethanol as an excuse to continue pumping subsidies into agriculture, now that traditional agricultural subsidies are limited by international agreements (WTO). Proponents argue that this policy generates vital environmental benefits (i.e. what appears to be subsidisation is actually a payment for positive externalities). More pragmatically they argue that these subsidies are spurring research and development in key future technologies (e.g. in wind power generation and biogas production) that will form a basis for future international competitiveness and economic growth in Germany. As fossil fuel prices increase on the one hand, and evidence on the extent and costs of global warning accumulates on the other, the proponents of government support for RES development and use are finding it increasingly easy to advance their arguments in public debate.

5. Conclusions

RES can provide a variety of direct and indirect economic, social and environmental benefits. Interest in RES has grown considerably of late, as fossil fuel prices have surged. Interest in RES is especially large in agriculture, because many RES are derived from agricultural production and because RES could provide local solutions to energy provision in rural areas.

To date, RES have been more expensive than alternatives based on fossil fuels. There are indications that this balance may be shifting, however. Fossil fuels are finite resources. They will become increasing scarce and expensive to extract. According to some calculations, at crude oil prices in excess of USD 40 per 1 barrel, it is more profitable for Brazil to process sugar into ethanol than to sell is as sugar for human consumption on world markets. Analogous calculations for manioc production in Thailand point to a cut-off price in the neighborhood of USD 45 per 1 barrel; for maize production in parts of the USA of USD 60 per 1 barrel; for some types of vegetable oil production of perhaps 50-60 USD per 1 barrel (in the latter case the alternative to food production is not ethanol but rather diesel fuel). There is also increasing awareness that many by-products of agricultural production (manure, straw) can be used as raw materials for RES production. Continued technological progress in RES can be expected to reduce the costs of generation. Furthermore, although it is notoriously difficult to value environmental benefits, accounting for these would significantly improve the relative competitiveness of some RES. The Kyoto Protocol can be seen as an attempt to institutionalize such an accounting.

Many countries have implemented policies and mechanisms to encourage increased use of RES. The EU has agreed on a set of medium-term goals for increasing the share of RES in electricity generation and transport fuel use. To attain these goals, Member States have introduced a variety of policies. For the most part these policies are expensive, burdening consumers by increasing energy prices, or taxpayers in the form of expenditure for subsidies or reduced public revenues due to tax exemptions for RES. Emulating such expensive policies would be difficult in Belarus, especially given the traditional emphasis places on maintaining low energy prices for households and the exceedingly high energy intensity of the national economy.

Authors: Prof. Dr. Stephan von Cramon, Elke Lakemeyer, Elena Rakova

Lecturer: Igor Pelipas

Minsk, November 2005

Appendix

Figure 6. Global primary energy consumption, 2002 (IEA)

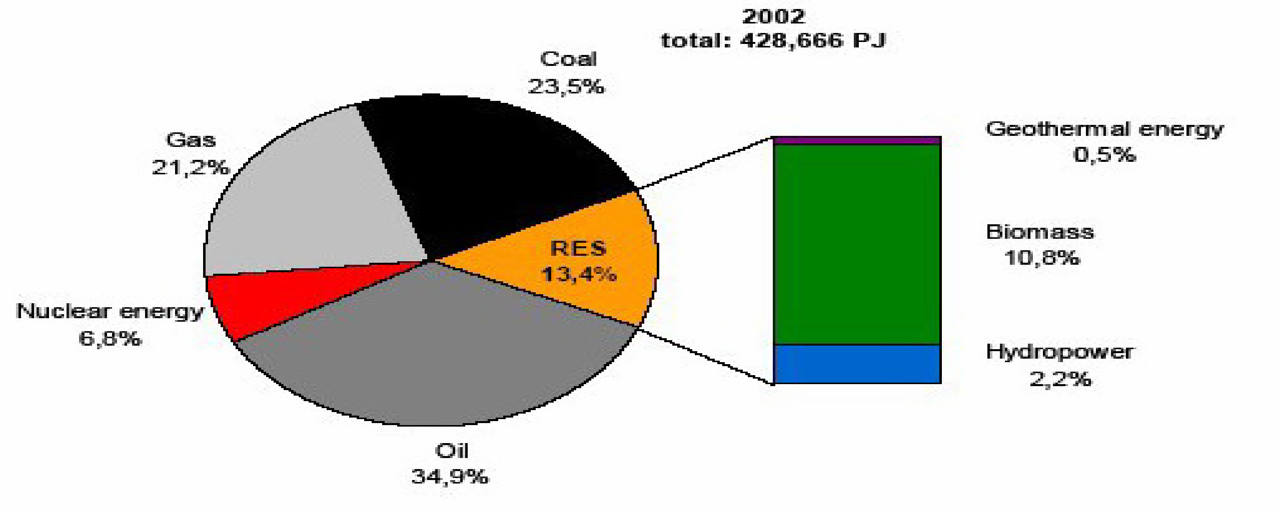


Figure 7: Share of RES in primary energy consumption in various regions, 2002. (IEA)

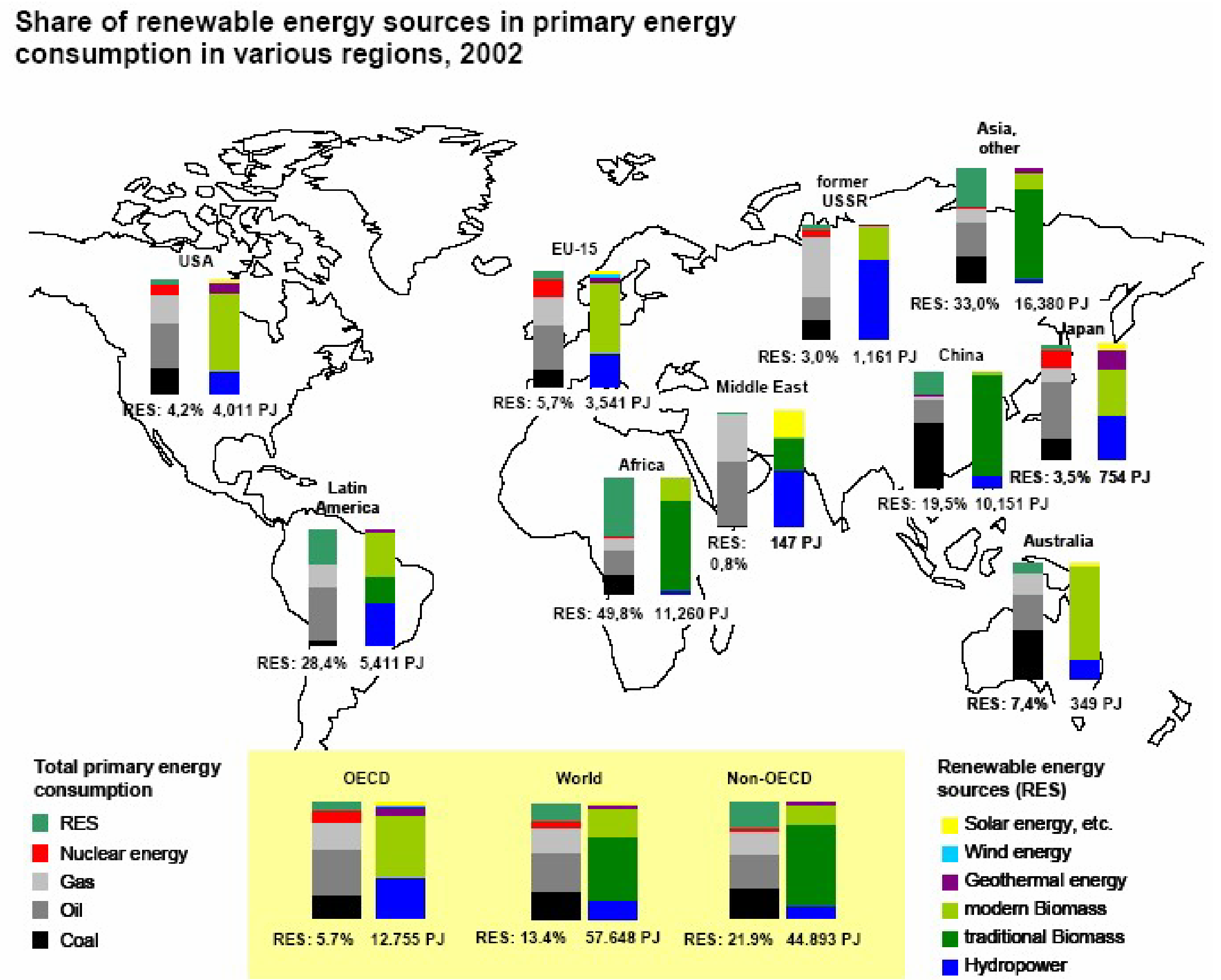
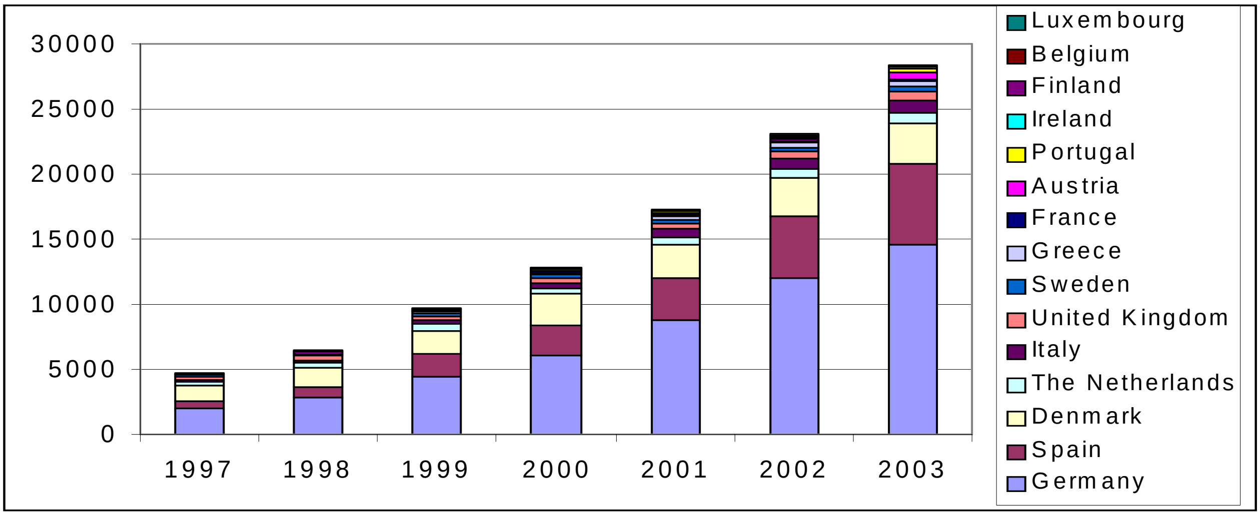


Figure 8. Wind energy capacity growth in EU15 1997-2003 – three leading markets



Source: European Commission, 2004.

Figure 9. Use and share of Renewable Energies in the EU 15, 2003

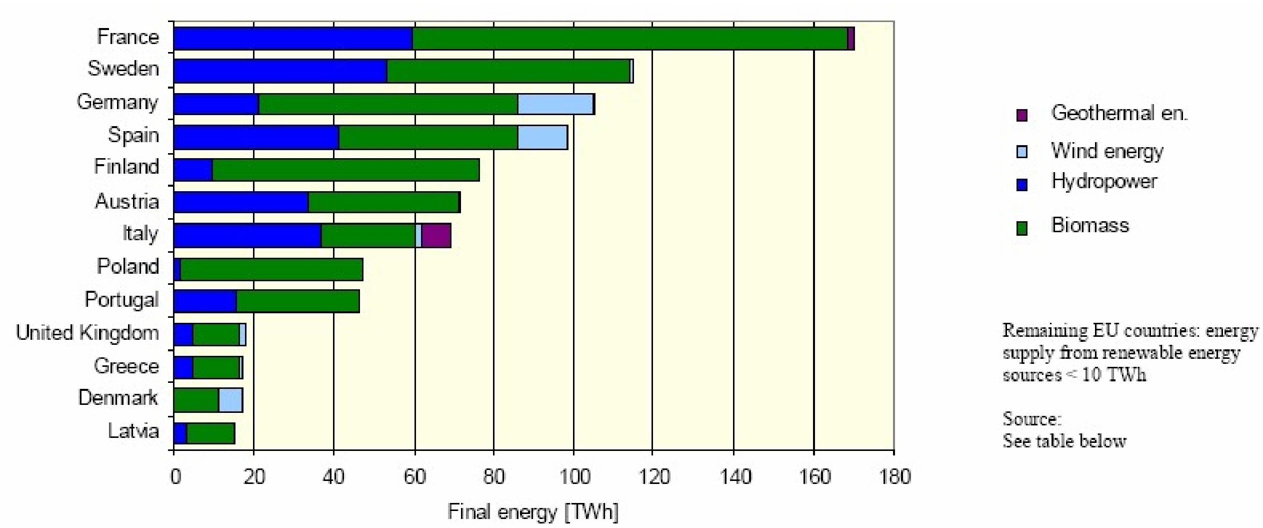
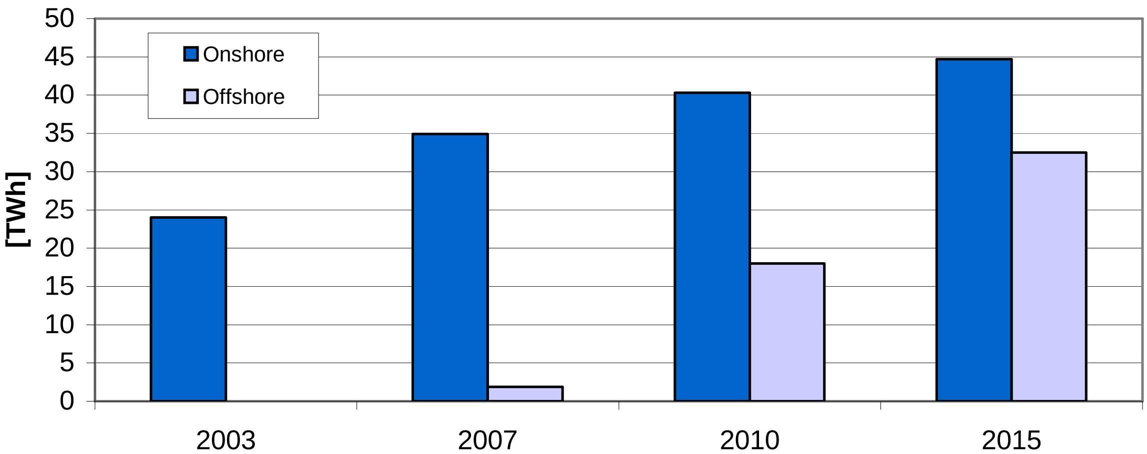


Figure 10. Development of the electricity production from wind power in Germany



Source: dena (2005)

Appendix 2. Brief definitions and descriptions of some basic terms

Table 1. Renewable Energy: Pros and Cons

Kind of RES	Advantages	Disadvantages
Biomass Biomass is the oldest of the renewable energy sources Bioenergy covers a large variety of routes, with many types of resources, many conversion technologies and three final energy products, heat, electricity and different types of liquid fuels for transportation	– Abundant and renewable Can be used to gain energy by using waste products.	– Burning biomass can result in air pollution – May not be cost effective.
Geothermal Geothermal is energy available as heat emitted from within the earth, usually in form of hot water or steam. The hot water can be used to heat buildings and any steam produced can be used to generate electricity.	– An unlimited supply of energy – Produces no air or water pollution.	– Best supplies limited to certain areas of the world – Start-up costs are expensive – Corrosion of pipes can be a problem. – Very site specific.
Hydroelectric Power Dams are built to control fast flowing rivers so that the water can be used to turn turbines to generate electricity. At times when the energy is not needed, the water can be pumped back up to the storage reservoir.	– Abundant, clean, and safe – Easily stored in reservoirs – Offers recreational benefits like boating, fishing, etc.	– Can have significant ecological and socio-economic impacts – Can be used only where there is a water supply.
Solar The sun's warmth can be used to heat water and buildings. Solar cells can convert sunlight into electricity.	– Unlimited supply – No water or air pollution.	– Reliability depends on sunlight – Not really cost effective at present – Storage and back-up are necessary.
Wind Power Tall wind turbines on wind farms can use the power of the wind to generate electricity. About 83 % of total installed capacity is in only 5 countries: Denmark, Germany, Italy, Spain and the U.S.	– Produces no water or air pollution Farmers can receive an income from any electricity generated and the land can have other uses.	– Constant wind is needed – The wind farms can have a significant visual impact – Wind farms need a lot of land. – Investment costs differ but are still high.

Table2. Belarus Primary Energy Supply and Consumption

	2000	2001	2002	2003	2004
Production					
crude oil (mt)	1.85	1.85	1.84	1.82	1.80
natural gas (bcm)	0.26	0.26	0.25	0.25	0.25
peat & wood (mt)	6.60	6.80	7.10	6.80	7.00
hydro (TWh)	0.03	0.03	0.03	0.03	0.03
Total Production (mtoe)*	3.25	3.28	3.32	3.25	3.27
Import					
crude oil (mt)	12.01	11.91	14.02	14.89	17.81
natural gas (bcm)	17.12	17.27	17.58	18.11	19.64
petroleum products (mt)	1.08	0.38	0.49	1.00	1.14
electricity (TWh)	7.22	8.32	6.79	7.40	4.05
coal (mt)	0.43	0.43	0.33	0.30	0.30
Total Import (mtoe)	28.92	28.52	30.58	32.53	35.99
Export					
Crude oil (mt)	0.35	0.40	0.60	0.80	1.05
petroleum products (mt)	7.78	7.66	9.88	10.54	12.96
electricity (TWh)	0.00	0.00	0.23	0.75	0.80
Total Export (mtoe)	8.13	8.06	10.54	11.53	14.21
Primary Energy Consumption (mtoe)	24.05	23.74	23.36	24.25	25.05

Note: A ton of oil equivalent is defined as 10 Gcal. The applied conversion factors are: coal, 0.39; crude oil and petroleum products, 1.0; natural gas, 0.81; peat and wood, 0.18; and electricity, 0.25.

Source: The Ministry of Statistics and Analysis and World Bank.